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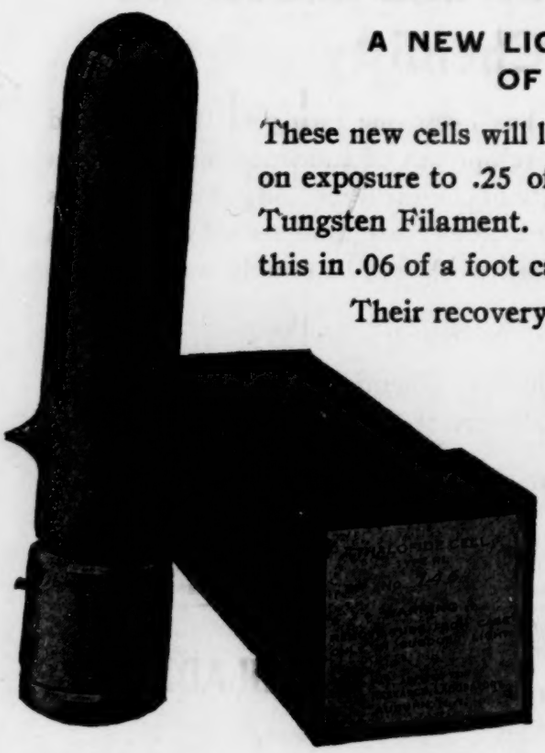

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CONTENTS

The American Association for the Advancement of Science:—

The Stimulation of Research after the War: PROFESSOR R. A. HARPER 473

James M. Macoun: DR. HARLAN I. SMITH.... 478

Scientific Events:—

The Anglo-American University Library for Central Europe; Publications for European Nations; Tables of the Motion of the Moon; The Director of the Bureau of Mines 480

Scientific Notes and News 483

University and Educational News 484

Discussion and Correspondence:—

The Aurora of March 22, 1920: PROFESSOR JOEL STEBBINS. *The Recent Auroras and Sun Spots:* PROFESSOR E. D. ROE, JR. *Possible Connection between Sunspots and Earthquakes:* PROFESSOR DINSMORE ALTER. *Some Micro-plankton from Salton Sea:* DR. W. E. ALLEN. *Conditions in Hungary:* PROFESSOR JAS. LEWIS HOWE. *Journals for Prague:* PROFESSOR FREDERICK S. HAMMETT. 485

Notes on Meteorology:—

The Supposed Recurrent Irregularities in the Annual March of Temperature: DR. CHARLES F. BROOKS 488

Special Articles:—

The Siphon in Text-books: DR. HAROLD C. BARKER 489

The American Association for the Advancement of Science:—

Section E—Geology and Geography: PROFESSOR ROLLIN T. CHAMBERLIN 491

The American Geophysical Union: DR. HARRY O. WOOD 494

The National Academy of Sciences 494

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THE STIMULATION OF RESEARCH AFTER THE WAR[1]

AT the time when I received from Dr. Cook the notice of my assignment to this topic, the phrase "after the war" seemed to be of rather indefinite and at least possibly remote significance. There was a chance at least that anything I might say would have time to be forgotten before its timeliness would be put to the test.

To-day we are face to face with the problem of stimulating research in this new epoch, which the political and social cataclysms of the past four years have ushered in. I am not one of those who are inclined to minimize the significance of the period through which we have just passed in its relations especially to the advance of knowledge. It is a reproach to biological science that we are not able to predict evolutionary trends, but it is perhaps on the whole a hopeful sign that we frequently differ so widely in our judgment of the significance of current events, and of the world problems which the great conflict involved.

It is for us, who conceive biology as in any true sense the science of life processes and activities in plants and animals alike from the lowest to the highest, to look to our fundamental conceptions and take thought of the responsibilities which our scientific pretensions involve. In my opinion we may find in the final assessment of responsibilities for the world war that a pseudo-scientific dogmatism, and the promulgation in popular form of superficial and wholly misleading views of such evolutionary concepts as the struggle for existence and the survival of the fittest, have had a share, both in the production of the false national and racial ambitions which lead up

[1] Read before Section G, American Association for the Advancement of Science, at the Baltimore meeting in the symposium on "Research after the War."

to the war, and the savage bitterness with which it was fought by its instigators.

It certainly behooves us as evolutionists to endeavor to clear up in a fashion not yet, in my opinion, adequately accomplished, the relation of Darwin's great concepts to such struggles, not that I assume that any one has the illuminating word now ready to be spoken. It is sufficiently obvious that a vast amount of further study of the problems and relations involved in the evolution of races, states, societies and civilization, as well as human individuals, is necessary before the concepts of struggle, progress, survival, etc., will attain a clearness which will finally prevent their use as the shibboleths of barbarism and savagery. As scientists we must all agree that in increased devotion to research and in the growth of that passion for understanding the living organism, its environment, its origin and its possibilities, our safety for the future lies. No ready made or lightly thought out theories will suffice. The danger from lightly conceived and lightly held political evolutionary theories promulgated by visionary and ill-trained statesmen and politicians, was never more real. The misuse of scientific half truths, misleading phrases and superficial analyses, was never more threatening than just now, when the central empires are endeavoring to regain their poise after their debauch of mad ambition. It is for scientists in the future to set an example of discriminating judgment and careful analysis of evidence of which they have not hitherto been capable.

The practical issues of the day we may say in a sense are still in the hands of men rather than of scientists and will be met and their problems solved instinctively and in accord with moral aspirations rather than by the application of established principles and concepts as to the nature and possibilities of further development of human societies and civilizations. The great men, the leaders, are so by virtue of an instinctive rather than analyzed feeling as to what is possible and achievable in the given conditions. The pragmatist with his worship of the man in the street may feel sure that this will always be the case, but in this assertion he loses whatever of truth there is in his philosophy and becomes the plain and familiar dogmatist of the past.

It is for us to see that a continually increasing number of those who are great leaders by virtue of their instinctive grasp of the significance of human movements and world situations, are also able to avail themselves of an increasing mass of analyzed and tested data bearing on the problems of life and evolutionary progress.

As a physiologist I may note that the stimulation of research does not involve the production of the fundamental motive power back of the advance of knowledge. Physiological stimuli liberate energies accumulated in the organism they guide and regulate activity but furnish no appreciable energy for its maintenance. They initiate reactions but do not cause them. The familiar illustrations of their nature and relations to organic activities are the pull on the trigger or the engineer's hand on the throttle. If there is no research mechanism well stocked with mental energy stimulation can do nothing. It may even weaken and destroy if the energies for normal reaction are not available.

Physiologically speaking the regulative stimuli, those wonderful activities of the enzymes and hormones which can accelerate or retard, direct and coordinate reactions so as to produce the complex and wonderfully adaptive phenomena of organic growth and behavior are those most interesting in present-day biological research and furnish the analogies on which the widespread demand for better control and coordination of scientific research is based. Why is it not our highest function as scientists to so regulate control and coordinate research that each problem shall receive its fit proportion of attention so that now when the world seems to need above all food supplies, a speedy physical rehabilitation to repair the wounds of war and a special set of political and social maxims for the use of nations in the transition from autocratic to more democratic governmental forms the whole energies of the world of science, political, social and biological, can be turned to producing these

desiderata. This would be efficiency in the German sense and a reasonable regard for such demands is necessary and desirable. There are, however, it seems to me, some more fundamental viewpoints that under stress of immediate physical need may be overlooked. And first among these is the fact that as noted stimulation, initiation, regulation, coordination, do not furnish motive power, imply indeed an exhaustion of energy rather than its increase. The withdrawal of men from the active prosecution of their own investigations in order that they may spend time on commissions, boards and other executive agencies for controlling and directing the research of others is doubtless a necessary evil but is in danger of being regarded as a useful end in itself. The activity of such agencies in securing funds and thus contributing to the motive power back of research is quite another matter but even there it is deplorable when a man of first-class talent withdraws from his own work and devotes his energies to obtaining financial support for a group who thus become in a sense his subordinates. If he makes efforts to direct and coordinate in detail the activities of such a group with their diverse capacities and widely separated lines of activity, his influence may even be positively harmful. The importance and advantage of cooperation in research have been very adequately and effectively presented from many quarters. The socialistic trend is obvious here as in so many phases of modern thought and action and it is at least worth while to consider what may be said from other viewpoints. Of spontaneous cooperation individually initiated there can not be too much, but if it becomes the fashion to work only in groups and on problems in which group interest can be aroused in my opinion we shall be disregarding many obvious teachings of experience. You may gather from this that I am not hopeful that research can be socialized in any very significant degree. It seems to me that this is especially true of those higher efforts of the human mind when it actually breaks over age old barriers or enters on wholly new and hitherto unsuspected fields for thought and action. Routine solutions of definite and simple problems can be achieved by the factory and piece work system but the highest achievements of the mind are always individual and seem frequently to mock all attempts to relate them to the environment or the period of their occurrence. In my opinion the distinction between routine research on the problems which are already clearly stated and for which methods of attack are obvious from data available and the studies which really open up new fields of hitherto unperceived interest and importance or solve problems long given up as ridiculous, is more significant than that between so-called pure and applied science. This distinction, it seems to me, has been overworked at least in its relations to the development of research. On the other hand, whether or no we conceive ourselves as either practically or theoretically able, by taking thought, to influence the course of events, it may tend to clearness of thought about what is actually going on in these times of turmoil and excitement if we recognize more fully that there are these two types of research activity, each with its own clearly marked prerequisites. The war experience of the nation has shown plainly enough that when the money and incentive are at hand staffs of experts can be organized and laboratories equipped on short notice which can solve a vast number of important problems relating to the chemistry of dyes, high explosives, gas warfare, aeroplane engines, etc., with a high degree of promptness and efficiency. I am sure too that we should be mistaken if we expect from such efforts only new applications of already known theoretic principles. We are perhaps quite as likely to arrive at theoretically significant new conceptions of matter and energy in the study of the vastly practical problems of static disturbances in wireless telegraphy (which problems by the way the newspapers recently announced had been solved by work in the laboratories of a great commercial corporation) as in the study of the wave theory of electricity as such with no practical problem in mind.

A vast amount of useful and theoretically highly important work is being turned out

yearly by investigators who either have definite problems assigned to them by others or who see a problem so clearly that they can at once present it to a board or committee or executive agency in charge of funds, and immediately win financial and other support for its study. We can not have too much of this sort of work and most of the research agencies now under consideration, such as the National Research Council, the various scientific departments of the national government, the research departments of the agricultural experiment stations, the great research institutions and commercial laboratories, are all well calculated to foster and develop work on problems whose possibility of solution is fairly evident or whose significance is already so fully understood that their study is suggested even though they seem for the time insoluble.

It seems to me equally obvious, however, that these agencies do not provide at all adequately for the second type of problems, those which at present lie outside of and beyond the domain of clear thought at least on the part of the majority of intelligent people, and this again quite regardless of whether the problems seem to relate to practical matters or to have only a theoretic or philosophical interest. I think we must admit that many of the great advances in knowledge have been made by some one's breaking over these bounds of the average scientists thinking and experimenting and attacking some problem which had been quite unthought of or was regarded so unclearly as to be considered wholly visionary, impossible of attack or even ridiculous. To illustrate, I think we must admit now that the Wright brothers were more favorably situated for the solution of the problem of human flight in heavier than air machines than was Langley. Langley was in a great government supported institution with supposedly all the resources for the attack on the problem from the mathematical, physical and experimental mechanical side at his command. The Wrights had to develop financial and other support as they went along. The case illustrates perfectly the weakness likely to inhere in governmentally supported research. Langley in his position, could not afford repeated failures in experimenting on a problem which was still regarded as chimerical if not ridiculous by the great mass of intelligent people of his time. The Wrights, working on their own initiative, with everything to win by final success and little to lose by temporary failure, with no explanations to make to governing boards or scientific societies, were in a vastly more helpful and normal environment, it seems to me, for establishing a new point of departure in a new field of activity. At least the Wrights succeeded and Langley was unable to push further his partial success in an achievement which if it had been followed up might have won him the distinction which went to the vastly less well supported efforts of the Wrights. Langley in his position under the eye of the government could not feel himself able to support temporary failure or even partial success, though in reality the endeavor was worth prosecuting through a thousand failures.

Another instance is the historic one of Pasteur's discovery of the relation of microorganisms to fermentation and decay. No more fundamental and enlightening work has been done in the whole history of biological research. It gave the final quietus to the doctrine of the spontaneous generation of germs in decaying organic matter and laid the foundations for a whole series of discoveries in theoretic pathology as well as applications in medicine and the practical arts. Yet if we accept the current accounts of the attitude of Pasteur's colleagues and the general public to his earlier work in these lines, we can see that it would have been quite impossible for him to have gained support in advance for his researches on problems supposed to be settled, or quite insoluble.

Pasteur, like the Wrights, won his way to popular support, but it is certainly a question whether the work, brilliant though it is, which has so far come from the great institute founded in his honor equals in significance the work done by the great master.

It is the despair of organizers of research that work of the first rank such as that of Pasteur and Darwin shows so little dependence on

facilities, equipment, etc., and it is always to be remembered that the problems on which they worked, and the results they achieved were not such as would have enabled them to win in advance either financial support or substantial recognition by the general public or their scientific colleagues. Pasteur could win his institute only by achieved results, not on an advance program for laying the foundations of a new science of bacteriology. Darwin could hardly have made the origin of species seem a promising and feasible field of research before he had the evidence of the efficiency of selection which made the whole subject of evolution a new and vital one. It is hardly conceivable that Darwin himself would have been able or willing to attempt to formulate in advance a project which would have covered the main field of his researches. He was working out into lines of thought and experimentation where clearness and feasibility became obvious after, and not before the event. In these days when in certain quarters it is assumed that every research must be outlined and made to appear reasonable in advance, it is worth while to remember that really new fields of study are very likely to look unpromising if not hopeless or ridiculous to the executive mind. If we require for every research project that it appear promising and workable within a so-called reasonable time, we put a premium on problems of the easy and less fundamental type. There is also a psychological factor here. The man who conceives vaguely at first a great new possibility in the advance of knowledge, is sometimes quite disinclined to talk about it merely because it seems so vague, hopeless, and perhaps even ridiculous. If we organize research to such a degree that it shall become the customary, if not the inevitable routine for every worker in an experiment station or research institute to feel that he can only work on problems which can be made to appear plausible and possible of solution in advance, we shall, as in so many socializing schemes, put a premium on mediocrity, and penalize real originality of the kind which has led in the past to many of the really great advances in knowledge.

It is, however, always to be remembered that there is probably a greater practical danger of our institutions of research becoming the refuges of incompetents and visionaries than that their methods will nip incipient genius in the bud. The illustrations I have used are, of course, extreme cases, and represent the exceptions rather than the rule as to the mass of scientific work now being done and which has been done in the past. It may well be said that the Darwins and Pasteurs will take care of themselves and that our plans and organizations should be for the average run of scientific workers. Still this objection overlooks the possibility that the case of the scientists, like that of other matters of heredity, can not be adequately analyzed on the basis of the simple assumption of "presence and absence" —in this case of genius. There are many grades of research ability. I have attempted to differentiate two classes of problems: first, those clearly conceived, and appearing more or less readily capable of solution; and second, those which, though obviously of vast importance if solved, are imperfectly conceived, or appear hopeless, or even fantastic. Still it is obvious enough that many if not most scientific problems lie somewhere between these extremes. Any problem which is worthy of serious effort will probably involve in its solution many lines of effort which were not foreseen at the beginning, and many important problems will seem, even to their projectors, too hopeless of solution to have any wide appeal, or to win adequate cooperative support, or even the approval of colleagues or superiors in attacking them.

In considering the whole problem of the stimulation of research we should recognize the limitations of controlled and directed effort, and learn if possible whether in our schemes provision can not also be made for that free and untrammeled environment where personal inclination and initiative are the major factors. Control and executive supervision become necessary in direct proportion as research is paid for directly as such. This is inevitable if government bureaus and research institutions are to be sure of some

return for their money. It is the special advantage of the universities that in them research can in a sense be regarded as a utilization of by-products—not infrequently in modern industry a very important source of real profits. The member of a university faculty can give a return for his salary in the form of teaching—the relatively prosaic, but important work of passing on to the new generation the achieved results of the science, literature and arts of the past with all which that implies of stimulus and moral development. This is his modicum of contribution, but beyond this, the spirit of the university, the environment of young students, the seminar, the scientific conferences, the intercourse with colleagues in related but diversified fields—all these are stimulants to research of the highest efficiency, and constitute at once that free and untrammeled environment which incites to effort in purely ideal lines where no consideration save the intrinsic interest of the work in itself, and the desirability of the solution to be attained need intrude. The universities because of their functions in teaching, are the natural homes for research on problems whose appeal is to the desire of the human mind to understand and control its environment.

I need hardly stop to add that all universities as yet do not furnish in the highest degree possible this sort of environment. It is enough for us that there is no intrinsic reason why they should not all become such centers of stimulation and motive power in research. And for the warning of those who are too much given to reforming that which is already reasonably good, be it said that the tyranny of majorities and of professorial trade unions is quite as likely to meet with passive resistance and the undermining effects of indifference and superior interest in the real work of teaching and research, as the attempts at financial, social, intellectual and executive overlordship which have in the past been regarded as the most insidious foes of our much-prized and too frequently little understood academic freedom.

The further fundamental consideration which confronts us is that after all research is hard work and that the most important stimulus thereto is the force of example. After the exhibition of the past four years it is hardly necessary to emphasize that man is still very much of an animal. One of the oldest if not the primitive mental trait is imitation. We shall stimulate research in direct proportion as we plunge into it ourselves each on the problems that look large and appeal to him especially. With the socializing tendencies of the present day and the vast emphasis which is being laid on organization it may sound like serious heresy but I am willing to stand for the proposition that in peace times at least no one is justified in assuming executive work or work in the planning and direction of the research of others to the exclusion of his own research work. On those minded to do so I would urge first at least the need of research that the justification of their viewpoint be made more clear than it is at present. With all our present-day divergence of views we can perhaps agree that the advance of knowledge in the future depends most on the possibility of winning the brightest minds of the rising generation for research and for accomplishing this it seems to me the most important factor is that we convince our students by our own examples that research is really an absorbing and satisfying occupation that it is interesting in itself even independently of the immediately obvious value of the results obtained. Not by preaching research or organizing research or talking about the stimulation of research, but by showing a deep, insatiable curiosity about the things of nature and of life, we shall advance and win others to engage in the pursuit and practise of knowledge

R. A. Harper
Columbia University

JAMES M. MACOUN

James M. Macoun, chief of the Biological Division of the Geological Survey, Canada, died January 8, 1920, aged 58. He was well known as one of the best informed systematic botanists, not only throughout Canada but also in other countries, and was an expert on the fur-seal industry.

During the summer of 1919, while conducting botanical field work in Jasper Park, Alberta, Mr. Macoun was taken ill but finished his field work before returning to Ottawa early in October. He became gradually worse and went to a hospital, but was found to be beyond surgical help.

Mr. Macoun was born in Belleville, Ontario, in 1862. The members of the Macoun family are known for their endeavors in scientific lines and as staunch workers for democratic good citizenship. Mr. Macoun was the son of Professor John Macoun, naturalist of the Geological Survey, Canada, now residing at Sidney, Vancouver Island, British Columbia. He was the brother of Mr. W. T. Macoun. Dominion Horticulturist at the Central Experimental Farm, Ottawa. The Macoun name is connected with practically all the botanical research work of Canada, and many of the plant species of Canada bear the name of Macoun. This alone is evidence of their authoritative standing in the botanical world. When young, James M. Macoun attended Belleville High School, and Albert College, where his father was then professor of botany.

In 1881, when nineteen years of age, he accompanied his father to the field on an exploration of the territory between Portage la Prairie, Manitoba, and the head waters of the Assiniboine.

In 1882, when his father, Professor Macoun, moved to Ottawa to take charge of the botanical and other natural history work of the Geological Survey, James came as his assistant, and he became a regular worker as a civil servant of the Dominion Government in 1883. In this service he continued for thirty-seven years, dying in harness. Mr. Macoun specialized in botany from the time he entered the service. He assisted his father in the preparation and publication of his monumental botanical work, and the two editions of the annotated list of the birds of Canada.

Mr. Macoun was appointed assistant naturalist of the survey in 1898. Since 1912, when his father moved to British Columbia, much greater responsibility was thrown on him, and he was appointed botanist in 1917. In 1918, because of his wide knowledge, he was appointed chief of the Biological Division.

In 1891, when the fur-seal industry of the Pacific Islands was a subject of diplomatic concern between Great Britain, Canada, and the United States, he was chosen by Dr. George M. Dawson, then director of the Geological Survey and Behring Sea Commissioner for Canada, to accompany him on a trip of investigation to Behring Sea. His services in the study of the life history and habits of the fur seal were so valuable that he was retained on this work in 1892 and 1893, and was sent to Europe as an expert in connection with the fur-seal arbitration.

In 1896 and in 1914 he was again sent to Behring Sea. In 1911 he spent 10 weeks in Washington as one of the Canadian representatives at the fur-seal conference. For his special international work in connection with the fur-seal he was highly commended by Lord Bryce, then British Ambassador at Washington, and received a C. M. G. for his services.

Mr. Macoun had his full share in the field work of the staff of the Geological Survey, which takes the members to many parts of Canada and mainly to the outlying or least civilized areas. On some of the expeditions he endured very severe hardships; for instance, in 1910, while studying the flora and fauna of the west coast of Hudson Bay, his ship was wrecked and the party had to attempt the return to civilization in a small boat. Fortunately they were rescued and taken to Fort Churchill, from where they made the overland trip to Lake Winnipeg on foot in the depth of winter, reaching the telegraph line after having been almost given up for lost. Mr. Macoun was always the leader in the morning and brought up the rear in the evening to see that no one was left behind to freeze. He always depreciated his own hardships on this trip and the importance of his effort, but it is no small task to bring forty men unacquainted with snowshoe travel, from Hudson Bay to Winnepeg in winter without loss of life or limb.

To Mr. Macoun and his father is due the

National Herbarium of the Geological Survey, containing over 100,000 specimens of the flora of Canada, and about half of the 14,000 ornithological specimens in the museum. Both were among the founders of the Museum of the Geological Survey.

Mr. Macoun was remarkably genial, had great ability as a clever conversationalist, and possessed a faculty to help those in need. He made many friends in all walks of life. "Labor" in particular will miss him greatly. His motto was "Equal opportunity for all," and this he strongly proclaimed through many organizations, whether wholly, in part, or not at all devoted to the interests of labor. Both labor and capital had so much faith in his fairness that they allowed him to act as sole arbitrator between them in the case of strikes. In this service he prevented much suffering among the ranks of labor, loss to capital, and inconvenience to the public. He took an active part in all work for the progress of humanity, engaging especially in work for the blind. During the war he was energetic in aiding relief measures; since then in assisting the returned soldier.

One of the most prominent civil servants of Canada, he did much to place the Civil Service Association on a firm basis, and was always a strong supporter of it. He was one of the founders of the People's Forum of Ottawa, and for a considerable time was its chairman.

He was active in municipal, provincial and Dominion affairs, and his interest in sociological questions took a practical turn. He was unostentatious in his wide philanthropies.

He was an individualist whose chief characteristics were his humanness, and his democratic life. He was affectionately and respectfully known as "Jim" across the continent, and prouder of it than of his C. M. G. He was never too busy to grant a word of advice and offer a word of cheer to any worker in any branch of science, to any one needing help, and to any worker for the common good.

Harlan I. Smith

Geological Survey,
Canada

SCIENTIFIC EVENTS

THE ANGLO-AMERICAN UNIVERSITY LIBRARY FOR CENTRAL EUROPE

It is proposed to establish in Central Europe under British-American auspices libraries of recent English books indispensable to university teachers. The work is being organized on a broad, non-political, non-sectarian basis, so as to enlist the widest possble cooperation. These libraries will supply on loan books needed by the faculties of the different universities in Central Europe. They will be under the charge of British and American representatives, and committees of the foreign universities will be asked to superintend the local administration. A committee of the six most important learned societies in Germany and Austria has been formed for the carrying out of the plan which, in addition to the loan library, will include a system of exchange of publications and duplicates between any libraries and institutions willing to cooperate. The preliminary statement of the trustees says:

> By thus taking the initiative in extending the hand of fellowship to colleagues in former enemy countries, British and American scholars are seizing a timely opportunity of helping to heal the wounds of the war and of exemplifying in a practical and convincing way the true "international mind."

Viscount Bryce, Lord Robert Cecil and other English public men have expressed their approval of the plan and have promised their cooperation in carrying it out. The supporters of the plan in Great Britain include: Gilbert Murray, Oxford; A. E. J. Rawlinson, Oxford; C. S. Sherrington, Oxford; Walter Raleigh, Oxford; A. E. Shipley, Cambridge; J. J. Thomson, Cambridge; A. S. Ramsay, Cambridge; Joseph Larmor, Cambridge; Horace Darwin, Cambridge; W. B. Hardy, M.A., Cambridge; Alfred Hopkinson, Glasgow; Col. E. H. Hills, Woolwich; Henry A. Miers, Oxford; Alex. Hill, Cambridge; George Paish, London; Rickman G. Godlee, London, and Michael Sadler, Leeds.

University teachers in the United Kingdom and American are requested to give their ap-

proval and cooperation to the plan by sending their names to the secretary, Mr. B. M. Headicar, librarian of the London School of Economics (University of London), Clare Market, London, W.C.

PUBLICATIONS FOR EUROPEAN NATIONS

OWING to the depreciated currency of Europe and the financial difficulties in which many European nations find themselves, the publication of some European serials has been temporarily discontinued, others have decreased in size, while the publication of still others is irregular. Furthermore, the purchase of American books at the present rate of exchange is practically impossible.

Since it is essential for the intellectual life of mankind, that students of all countries should be in close touch, and since it seems of importance to America that the results of our intellectual activities should be known, the undersigned urge all publishers, publishing institutions and publishing societies to exchange their publications on the most liberal terms with libraries, publishers, journals and publishing institutions and societies of all European countries, disregarding for the near future the question whether the amount of printed matter received in exchange corresponds with the amount sent.

(*Signed*) Felix Adler, James R. Angell, Franz Boas, Charles W. Eliot, J. Cardinal Gibbons, Arthur T. Hadley, David Starr Jordan, Harry Pratt Judson, E. H. Lewinski-Corwin, A. Lawrence Lowell, John Bassett Moore, Henry Fairfield Osborn, George Foster Peabody, M. I. Pupin, Jacob Gould Schurman, Ellery Sedgwick, F. J. V. Skiff, Munroe Smith, Antonio Stella, Henry Suzzallo, Harlan F. Stone, William H. Taft, F. A. Vanderlip.

TABLES OF THE MOTION OF THE MOON

THE "Tables of the Motion of the Moon," by Ernest W. Brown, Sc.D., professor of mathematics in Yale University, has now been published through the Yale University Press. It is the result of thirty years of research and preparation.

The first tables of the moon, founded on the law of gravitation, were published by Clairaut in 1752, but the tables published in 1857 by Hansen were the first which permitted the position of the moon to be computed from theory with an accuracy comparable with that of observation. The only other set of like importance is the tables founded on Delaunay's theory, appearing in 1911 under the final direction of Radau. These have been used for the ephemerides of the moon since their publication. The appearance of Professor Brown's tables is expected to constitute a new epoch in the history of astronomical tables, and to exercise a marked effect on navigation.

Professor Brown, a graduate of Christ's College, Cambridge, has held the chair of mathematics at Yale University since 1907, having previously been professor at Haverford College. He is the author of "Treatise on the Lunar Theory," 1896; "A New Theory of the Moon's Motion," 1897 to 1905; and of many papers on the lunar theory and on celestial and general mechanics. He received the gold medal of the Royal Astronomical Society in 1907, and the Royal Medal in 1914. The latest honor which has come to him is the Bruce medal of the Astronomical Society of the Pacific, which he recently went to San Francisco to accept.

Professor Brown is a fellow of the Royal Society and of the Royal Astronomical Society, a member of the London Mathematical Society, the Cambridge Philosophical Society, the American Philosophical Society, the American Mathematical Society, of which he was president from 1914 to 1916, the American Association for the Advancement of Science, being vice-president of Section A in 1910, and the American Academy of Arts and Sciences.

The work of Professor Brown has been printed in three parts, bound in paper covers in order that the various purchasers of the tables may bind them to suit their individual needs. The book has been printed on handmade paper, by the Cambridge University Press in Cambridge, the size of the page being 10¼ by 13⅝ inches. In concluding his preface to the "Tables of the Motion of the Moon" Professor Brown has made the following statement:

This volume brings to a close the work started thirty years ago with a study of Hill's papers made at the suggestion of my former teacher and friend, George Darwin. The undertaking of a complete recalculation of the moon's motions and later of tables which should make the theory available for practical and scientific use was no ambitious plan formed at the beginning but grew naturally out of the desire to continue the work as each stage in it was reached. Some part of it has always been in progress and there have been long periods during which it has been my sole occupation outside of the duties connected with an academic position and of the hours given to recreation. The word "finis" brings with it some feeling of regret. The time spent in actual calculation was often a relief from attempts to solve more difficult problems in other lines. To what extent it has been worth while as a contribution to the subject must be left to the future and to others for judgment. My hope is that it will give some aid in unravelling the tangled skeins of problems which our nearest celestial neighbor has never failed to present, and that the satisfaction to myself in seeing the work finally brought to a conclusion will be shared by those who have been interested in watching its progress.

THE DIRECTOR OF THE BUREAU OF MINES

The nomination of Dr. Frederick G. Cottrell for director of the Bureau of Mines, Department of the Interior, was sent to the Senate on May 5 by President Wilson, to take the place of Dr. Van. H. Manning, resigned. Dr. Cottrell was the assistant director of the bureau under Dr. Manning.

Frederick G. Cottrell, chemist, metallurgist and inventor, was born in Oakland, Calif., January 10, 1877. He attended school in Oakland and matriculated at the University of California in 1892. As a university student he gave especial attention to science, particularly chemistry. After graduation in 1896, with the degree of bachelor of science, he was a Le Conte fellow at the University in 1896–1897 and taught chemistry at the Oakland High School in 1897–1900. Then he went to Europe, where in 1901 and 1902 he studied at the University of Berlin and the University of Leipzig, receiving from the latter the degree of doctor of philosophy in 1902. On his return to this country in 1902, he was appointed instructor in physical chemistry at the University of California, and in 1906 was appointed assistant professor, holding this position until 1911. While at the university Dr. Cottrell's chief contributions to science were researches relating to the electrical precipitation of fume and fine particles suspended in the gases of smelter, blast furnace or cement works flues, and he finally evolved what is known as the Cottrell process for this purpose. This invention was first utilized at the Selby smelter in California for removing fumes from the waste gases of a sulphuric acid plant at the smelter, thereby abating a nuisance that threatened to necessitate shutting down the works. Subsequently this electrical precipitation process was installed at other smelters to remove fume and solid particles contained in the escaping gases, and it was also successfully used at cement plants, notably near Riverside, Calif., to prevent the dust from calcining kilns from damaging nearby orange groves and vegetation. To-day the Cottrell process of fume and dust removal is in world-wide use, and is recovering materials heretofore wasted to the value of many thousands of dollars. One of the latest installations is at a large smelting plant in Japan; while the largest installation is at the Anaconda smelter, Anaconda, Mont. Dr. Cottrell in a desire to encourage scientific research turned over his extensive patent rights to a non-dividend-paying corporation, known as the Research Corporation, a body formed for that purpose. A fundamental requirement in the incorporation is that all net profits shall be devoted to the interests of scientific research.

In 1911 when Dr J. A. Holmes, the first director of the Bureau of Mines, was serving as a member of commissions appointed by the government to study alleged damages from smoke and fumes from the Selby and the Anaconda smelters, and the Bureau of Mines was investigating at length the smelter-smoke problem, Dr. Cottrell, because of his scientific attainments and his special knowledge of metallurgical problems, was appointed chief physical chemist in the bureau. In 1914 he

was appointed chief chemist, in 1916, chief metallurgist, and in 1919, assistant director.

Aside from his work on smelter smoke Dr. Cottrell has been intimately connected with work on the separation and purification of gases by liquification and fractional distillation. During the world war and subsequently the development of the Norton or Bureau of Mines process for the recovery of helium from natural gas has been his special care, and it was chiefly through his efforts that a plant for recovering helium on a large scale for military aeronautics has been erected near Petrolia, Texas.

Dr. Cottrell is a member of the American Chemical Society, Mining and Metallurgical Society of America, the American Electrochemical Society, the American Institute of Mining and Metallurgical Engineers, and the American Association for the Advancement of Science. He was awarded the Perkin medal by the New York Section of the Society of Chemical Industry in 1919 in recognition of his work on electrical precipitation.

SCIENTIFIC NOTES AND NEWS

DR. AUGUSTUS TROWBRIDGE, professor of physics at Princeton University, during the war lieutenant colonel and head of the sound ranging service of the A. E. F., has accepted appointment as chairman of the division of astronomy, mathematics and physics of the National Research Council for the year beginning on July 1.

DR. HUBERT WORK, of Colorado, first speaker of the house of delegates of the American Medical Association, has been elected president of the association.

THE council of the British Medical Association, at the meeting of April 14, resolved unanimously to recommend the Annual Representative Meeting that Dr. David Drummond, should be elected president of the association for the year 1921–22, to take office at the Annual Meeting to be held at Newcastle-on-Tyne in 1921. Dr. Drummond is vice-chancellor and professor of medicine, University of Durham, and consulting physician, Royal Victoria Infirmary, Newcastle. The council decided also to accept an invitation from the Glasgow and West of Scotland Branch to hold the annual meeting of 1922 in Glasgow.

DR. OTTO KLOTZ, director of the Dominion Observatory, has been elected president of the Seismological Society of America.

DR. WILLIAM H. WELCH and Dr. Ira Remsen, both of Johns Hopkins University, have been appointed to the Board of Electors for the Hall of Fame of New York University.

DR. JOHN H. FINLEY has received the gold medal of the Geographical Society of Paris, in recognition of the English edition of his book, "The French in the Heart of America." The French edition of the same work was crowned by the *Academie* with an award of 1,500 francs.

PROFESSOR RAY S. OWEN, of the department of topographic and highway engineering of the University of Wisconsin, has been made Officier d'Academie by the French government for his work in the intelligence department of the army.

THE Howard Taylor Ricketts prize of the University of Chicago for 1920 has been awarded to Ivan C. Hall for his work on "Studies in Anaerobiology." This prize is awarded annually on May 3, this being the anniversary of the death of Dr. Ricketts from typhus fever while engaged in investigative work on this disease in Mexico City in 1910.

THE Boylston Prize of $300 has been awarded to Messrs. Stuart Mudd, Samuel B. Grant and Alfred Goldman, fourth year students of medicine, for their research on "The Effect of Chilling on the Mucous Membrane of the Throat and Tonsil," performed in the pathological laboratory of the Washington University School of Medicine.

DR. LYMAN J. BRIGGS, formerly physicist in the Bureau of Plant Industry, U. S. Department of Agriculture, who had been on temporary assignment to the Bureau of Standards for research on aeroplane problems during the war, has been transferred per-

manently to the staff of the Bureau of Standards.

H. H. Hansen, chemist in charge of feeding stuff analysis in the West Virginia Experiment Station, has been appointed state chemist of Delaware in charge of a new laboratory which has been equipped in Dover, by the State Department of Agriculture to conduct the chemical and seed testing work of the state.

Dr. Arthur W. Dox has resigned as chief in chemistry of the Iowa Agricultural Experiment Station to accept the position of research chemist for Parke, Davis & Co., Detroit, Mich.

Dr. E. H. Starling, professor of physiology in the University of London, who has gone to India to advise the British government with regard to the foundation of a central medical research institute for India, will visit Bombay, Poona, Bangalore, Calcutta, Delhi and Kasauli.

Professor Richard P. Strong, of Harvard University, will attend the annual congress of the British Royal Institute of Public Health, which is to be held this year, upon special invitation from Belgium, from May 20 to 24, in the city of Brussels.

Joseph T. Singewald, Jr., associate professor of economic geology at the Johns Hopkins University, who has been on leave of absence since December to carry on geologic investigations in Peru, has returned to Baltimore.

Dr. Willard J. Fisher, assistant professor of physics in the University of the Philippines, and since July, 1919, acting head of the department, is leaving the university to return to the United States this summer.

Mr. Calvert Townley, president of the American Institute of Electrical Engineers, visited the sections of that body at Chicago, Milwaukee, Ann Arbor, Detroit and Toronto during April. He delivered addresses at each place.

The meeting of the New York Section of the American Chemical Society on the evening of May 7 was devoted to papers on the general subject of Colloids and Colloidal Chemistry in accordance with the following program: "The general chemistry of gelatine," by Jacques Loeb; "Silica gel and its uses," by W. A. Patrick, and "Electroendosmosis," by T. R. Briggs.

A Liebig museum was opened at Giessen on March 26, when an address was given by Professor Burger on the relation of Liebig to medicine.

Applications for three Ramsay memorial fellowships for chemical research will be considered by the trustees. They must be received by June 15, by Dr. W. W. Seton, organizing secretary, Ramsay Memorial Fund, University College, London. The fellowships will each be of the annual value of £250, with, possibly, a grant of not more than £50 per annum for expenses, and tenable for two years, with the possible extension of a year.

Dr. E. Schwalbe, director of the pathological institute at the University of Rostock, was killed during the recent rioting.

UNIVERSITY AND EDUCATIONAL NEWS

The Mississippi legislature has appropriated $250,000 for a new chemical building at the University of Mississippi which will provide laboratory and other facilities for students in the medical school. An additional appropriation of $10,000 was made to secure permanent equipment for the medical school, exclusive of chemistry. Additional funds were appropriated for the university with which salaries of all teachers could be reasonably increased. The total appropriation for the university exceeds $1,000,000.

Mr. F. A. Heron has given to Queen's University, Belfast, the sum of £5,000 to provide the necessary equipment for teaching physical chemistry, and £1,000 towards the provision of accommodation for the department.

James T. Jardine, investigator for the United States Forest Service, has been elected director of the Oregon Agricultural College Experiment Station.

A. H. FULLER, director of engineering at Lafayette College, and previously dean of engineering at the University of Washington, has been appointed head of the civil engineering department of Iowa State College at Ames, and will take up his new duties about the first of July.

DR. OTTO V. HUFFMAN, who has resigned as dean of the Long Island College Hospital and has resumed practise in New York City, has been appointed a member of the faculty of the New York Post Graduate Medical School and Hospital in the department of internal medicine.

PROFESSOR F. B. ISELY, of Central College, Fayette, Mo., has accepted the position of dean and professor of biology at Culver-Stockton College, Canton, Mo., and will begin work in June.

AT Yale University instructors have been appointed as follows: Leonard H. Caldwell, in engineering drawing; Arthur H. Smith, in physiological chemistry; Wilbur Willis Swingle, in biology; J. H. Fithian, Jr., and Howard B. Meek, in mathematics.

MR. JOHN B. FERGUSON, formerly of the Geophysical Laboratory, of the Carnegie Institution of Washington, and now a member of the research department of the Western Electric Company of New York City, has accepted a position as associate professor of chemical research at the University of Toronto.

DR. J. H. ANDREW, chief of the Metallurgical Research Department of Sir W. G. Armstrong, Whitworth, and Co., Manchester, has been appointed to the chair of metallurgy in the Royal Technical College, Glasgow, vacant by the transfer of Dr. Desch to the University of Sheffield.

DISCUSSION AND CORRESPONDENCE

THE AURORA OF MARCH 22, 1920

THE bright aurora of March 22 was first noticed at Urbana about 7:00 P.M. It must have developed quickly, for I had glanced over the entire sky looking for clouds at 6:45, without noticing anything unusual. Soon after 7:00 the illumination was covering more than half of the sky but it was a couple of hours before the streamers were well marked near the magnetic zenith. This aurora was the longest in duration I have ever noticed at Urbana, as it was followed continuously from 7^h to 13^h, and observations of the apparent radiant were made at times during two hours. My assistant, Mr. C. C. Wylie, was also watching the display from a position a quarter of a mile distant from the observatory, and our independent estimates of the apparent radiant or focus of the streamers high up in the south, are given in the table. The times are Central Standard Time, 6 hours slow of Greenwich Mean Time.

C. S. T.	Declination	Hour Angle	Observer	Remarks
$9^h\ 05^m$	20°.8	+4°.0	S	
9 08	21.3	+3.8	S	
9 22	20.6	+1.2	S	
9 25	19.0	+1.1	W	Fair
10 05	20.4	−4.8	W	Fair
10 09	20.7	+2.5	S	Fair
10 21	19.6	+3.0	S	
10 22	22.3	+2.0	W	Good
10 25	20.0	+2.8	S	Good
10 34	20.7	+0.2	S	Good
10 55	21.0	−1.6	W	Good
11 12	20.5	+1.5	S	Fair
11 12	19.1	+0.0	W	Good
11 18	20.5	+0.2	S	Fair
Mean of S's	20°.5	+2°.1		
Mean of W's	20.4	−0.7		
Mean of all	20.5	+1.1		
Magnetic zenith	21.2	+1.1		
Difference	0.7	0.0		

The mean of all estimates differed by only 0.°7 from the magnetic zenith, as defined by the magnetic elements for Urbana determined by Mr. Merrymon of the Coast Survey in 1917. This agrees with previous results.[1]

The auroral light interfered with our photometric observations at the telescope that evening, because of the variable bright sky background for any star. A few rough measures gave the result that a patch of auroral streamer equal in apparent area to the full moon gave about as much light as a second

[1] SCIENCE, 47, 314, 1918.

magnitude star. This refers to the blue light which most affects the photo-electric cell, which is not very different from the photographic plate in color sensitivity.

Joel Stebbins
University of Illinois Observatory

THE RECENT AURORAS AND SUN SPOTS

The object of this preliminary communication is to call attention to the coincidence with the recent magnetic displays of a huge disturbance on the sun approximately parallel to the sun's equator and over 205,000 miles long so situated that the whole of it approximately passed centrally requiring at least two days for its passage over the sun's center. The group of spots consisted of at least six larger and numerous smaller ones, all stringing along in a line. My first observation of it was on the 23d of March when most of the group had already passed the center by about a day. If the group existed prior to the 23d without essential modification, it began to pass the center between the 20th and 21st, showing a lag in the propagation from the sun to the earth, if there be such, of something like two days. This seems to favor Professor Snyder's recently announced statement that there is a lag of 48 hours. The observation seems at least to point to the fact of there being some kind of propagation. The central passage required about two days and the aurora was evident on the evenings of the 22d and 23d at least.

Again on the 16th of April a medium-sized spot became central. It was probably one of the six spots of the before mentioned group. It was followed by a small spot some 200,000 miles after and also central about two days later. It was possibly another remnant of the old group, but too small to be of any consequence. It had disappeared by the 19th. Two or three days before the medium-sized spot became central, I remarked to several of my colleagues that I would not be surprised at auroral display or at least magnetic disturbances after it passed the center. I saw no aurora, the sky was unfavorable, and probably also the time, but on the morning of the 17th telegraph operators noticed a disturbance, which must have been due to the alleged propagation. If so the lag was about one day in this case.

My measurements of the positions of all the spots were made on the sun's disc directly with the micrometer and will yield heliographic latitudes and longitudes of all the points observed, but I have had no time to make the computations. I would wish this communication to be considered as a first approximation to more accurate values.

E. D. Roe, Jr.
Syracuse University,
April 24, 1920

POSSIBLE CONNECTION BETWEEN SUNSPOTS AND EARTHQUAKES

In Monthly Notices of the Royal Astronomical Society for April, 1919, Professor H. H. Turner has discussed data taken from the Catalogue of Destructive Earthquakes compiled by Milne and from the Catalogue of Chinese Earthquakes. He publishes tables of earthquakes extending back to 49 A.D. and refers to old Chinese records dating to 1820 B.C.

From these data he slightly modifies two suspected earthquake periods, first published in the Report of the Seismological Committee to the British Association in 1912. The short period is shown by him to have minor and major limits of 14.8421 and 14.8448 months. The long period is taken as seventy-eight years. His tables show these periods almost certainly as real.

Nine times the limits of the short period give 11.1316 and 11.1336 years. Newcomb has derived the sunspot period as 11.13 years and Larmor and Yamaga as 11.125 years. The chance that this close commensurability is accidental is as the difference, which is less than one one-hundredth of a year, is to the period of about 1.24 years. That is about one in two hundred and fifty.

If the short period is so nearly commensurable the long period must be also. Seven times the sunspot period is 77.91 years, agreeing to 0.09 years with his round figure of seventy-eight years.

It would be interesting in this connection to analyze the counts by months of sunspots through several cycles to find whether there is any evidence of a short-period variation of this length, no matter how small. I hope to be able to do this within the next few months.

DINSMORE ALTER

UNIVERSITY OF KANSAS

SOME MICRO-PLANKTON FROM SALTON SEA

As is generally known Salton Sea is a body of water covering a part of the Imperial Valley in southern California which is 230 feet below sea level, and it is formed by overflow of flood waters, or by waters diverted for irrigation, from the delta of the Colorado River.

On December 16, 1919, Captain W. C. Crandall, of the Scripps Institution for Biological Research of the University of California, Dr. H. C. Bryant, of the California State Fish and Game Commission, and of the museum of vertebrate zoology of the University of California, and Dr. Will F. Thompson, of the California State Fish and Game Commission, started over the recently completed San Diego and Arizona railroad for a four days' biological investigation of Salton Sea.

Captain Crandall made a few plankton catches in Salton Sea and secured a number of water samples, temperatures, etc., besides making some rough physiographic observations. Dr. Bryant found about fifty different kinds of birds. Dr. Thompson's fishing equipment did not get through so he was not able to make the expected studies of fish. It was found, however, that Salton Sea is regularly fished for mullet which reach large size and are found in commercial quantities at present.

Four hauls were made for microplankton in Salton Sea with a fine (Number 25) silk net such as has been in use for some time for marine work. The catches thus made were purely qualitative and were taken at the surface under adverse conditions. One catch indicated a rather abundant microplankton. Catches made at other points showed very little. The presence of the following organisms was noted in a hasty examination of the catches: *Keratella quadrata* (Müller), *Brachionus pala* Ehr., (most of these had female eggs attached), *Anabæna* sp., *Oscillatoria* sp., *Cœlastrum* sp., *Amphiprora alata* Kuetz., *Fragillaria crotonensis* Kitton, *Navicula* sp., and *Surirella* sp.

Physiographic features of Salton Sea are very remarkable. There has been a fairly constant reduction of level at the rate of about one foot per year for some years. Consequent recession of the water has left exposed numerous mud geysers, hot and cold springs, various types of mineral springs and some excellent paint pigments almost ready for use. In the sea itself, near the mouths of its tributaries, it is notable that the water is in two layers, the heavy saline water below and the relatively fresh above. It thus resembles ocean conditions near tributaries.

The primary purpose of this memorandum is to call general attention to the fact that the Salton Sea locality offers extraordinary favorable conditions for continuous studies throughout the year in the lines of physiography, hydrography and biology. Since the microplankton is the biological group which gives the clearest index to biological conditions in water, it would be especially desirable to have that particular phase of biological study carried on. There is probably no other body of water in the world so favorably situated and conditioned for segregation and evaluation of major factors involved. It would be most fortunate for the progress of science in general if a biological station could be established in this region and its work assisted by that of a competent physiographer and hydrographer.

W. E. ALLEN

SCRIPPS INSTITUTION,
LA JOLLA, CALIFORNIA

CONDITIONS IN HUNGARY

TO THE EDITOR OF SCIENCE: I have just received a letter from a professor in Hungary, which should, I think, be shared with the readers of SCIENCE. The writer is one of the leading scholars in that country in his department, and with him for many years prior to the war I have had a most pleasant acquaintance. I know that only real suffering

on the part of his friends and himself could have induced him to write this letter, from which I take the following extracts:

. . . "The middle classes are suffering frightfully in the present depreciation of money. Our salaries (which are for the present being paid) seem high according to the figures, but they are insufficient for the purchase of even the ordinary necessities of life. We may, for instance, possibly once a week have a bit of meat, but for the rest of the time we have to rejoice if we can get enough bad bread and vegetables to appease hunger. Sugar is enormously dear and never to be had in sufficient quantities. Clothing we can not buy, for a single simple suit would cost more than a month's salary. It is the same with underclothes and shoes. What our present conditions will lead to in the near future it is impossible to conceive."

. . . "You can imagine it is in the highest degree painful for me to write you such a letter, and only real suffering would justify it."

. . . "While we are suffering in Austria from actual need of food, packages of food sent by individuals in America rarely reach their destination. Money is practically of no value, for there is little food to be purchased with it."

Professor ———, whose name I withhold, writes that the American Relief Administration (whose office in this country is at 115 Broadway, New York), has established an American food warehouse in Vienna, from which food is distributed that has been shipped from this country.

Jas. Lewis Howe

Washington and Lee University,
Lexington, Virginia

JOURNALS FOR PRAGUE

To the Editor of Science: Dr. M. Kojima, surgeon-commander, Japanese Navy, has but now arrived from Tchecho-Slovak where he visited Professor A. Biedl. The latter has sent through him a message to American scientists asking if they can arrange to have sent to him the various scientific publications and periodicals, since he is unable to purchase the same on account of the rate of exchange, lack of funds, and general disturbed conditions in Tchecho-Slovak. It seems to me that the least we can do is to arrange through our editing boards some procedure by which Dr. Biedl may receive current numbers of our scientific periodicals. I would appreciate greatly your giving this communication publicity in "Science." Dr. Biedl's address is Das Institute fur Experimentelle Pathologie, Prag, Tchecho-Slovak.

Frederick S. Hammett

NOTES ON METEOROLOGY

THE SUPPOSED RECURRENT IRREGULARITIES IN THE ANNUAL MARCH OF TEMPERATURE

"The belief that periods of unseasonable heat and cold tend to recur at or about the same time from year to year has prevailed over a great part of the world for many centuries and has been the subject of extensive scientific investigation." This is the opening sentence in an extensive, scholarly discussion of the "Literature concerning supposed recurrent irregularities in the annual March of temperature," by C. Fitzhugh Talman, librarian of the Weather Bureau.[6]

Most of the literature deals with a cold period in May.

Over a considerable part of continental Europe it has been popularly believed since the Middle Ages that destructive frosts were likely to occur at a certain period in the month of May, and with the elaboration of the ecclesiastical calendar these frosts became definitely associated with the days dedicated to Saints Mamertus, Pancras and Servatius (May 11, 12, 13), or, in south-central Europe, Saints Pancras, Servatius and Boniface (May 12, 13, 14), hence known as the "ice saints." . . . With the construction of synoptic weather charts, the barometric conditions that accompany depressions of temperature gradually became apparent. . . . [This cold period] was found to occur when, owing to the rapid warming of the land regions as compared with the ocean, a center of low barometric pressure develops over southeastern Europe while high pressure prevails over the ocean

[6] *Monthly Weather Review*, August, 1919, Vol. 47, pp. 555–565.

to the northwest, a situation that gives rise to cold northerly and northeasterly winds in central Europe. . . . While the immediate causes of these interruptions of temperature has thus been made clear, it is not yet certain whether or to what extent such interruptions, with their attendant barometric conditions tend to recur from year to year on certain dates, such as the days of the ice saints. Irregularities in a curve showing the mean annual march of temperature as deduced from a record of 50 or 100 years may be due to excessive departures in particular years rather than to a real tendency to recurrence on particular dates, and, on the other hand, a tendency to recurrence might not manifest itself in the mean curve, especially, if as some students have surmised the phenomenon is one that undergoes periodic fluctuations.

Bearing on this question is a mathematical discussion by Professor C. F. Marvin, entitled, "Normal temperatures (daily): are irregularities in the annual march of temperature persistent?"[7] Average annual temperature curves based on the averages of the means of each week over a period of years, may be well-covered mathematically in a curve of one or two harmonics. The residuals, which in a given period are much the same over a large part of the eastern United States, are mostly due to some extreme departures occurring in a single year of the record: which throws doubt on the existence of recurrent irregularities.

Professor Marvin's mathematical analysis of only 15-year averages shows that it is possible to get a surprisingly accurate, smoothed, normal annual temperature curve from a short record.

NOTES

The *Monthly Weather Review*[8] contains so much material that these occasional notes in SCIENCE have by no means covered even a majority of the 150 contributions, not to mention hundreds of abstracts and other items of meteorological interest, published during the past year. For a brief summary and mention of many of the important contributions published during 1919, and the reader is referred to the American Year Book; and for the articles and notes themselves, to the *Monthly Weather Review* files maintained at all Weather Bureau stations, and at a few hundred college, university and public libraries.

Hereafter, these notes on meteorology and climatology for SCIENCE will be continued by Mr. C. LeRoy Meisinger, assistant editor of the *Monthly Weather Review*.

CHARLES F. BROOKS

WASHINGTON, D. C.

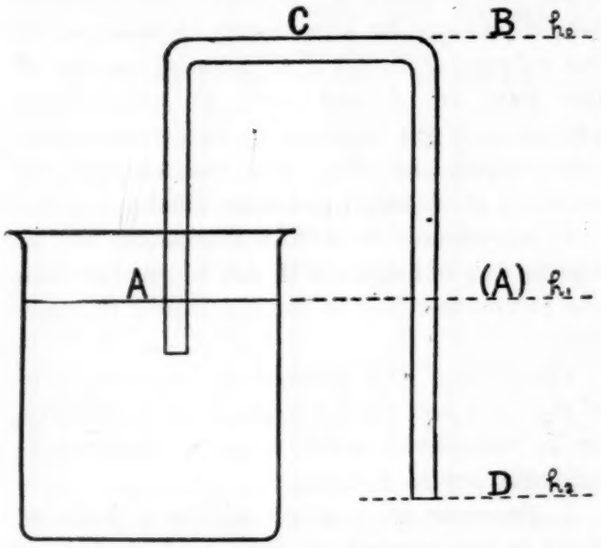
[7] *Ibid.*, pp. 544–555, 4 plates, fig.

[8] Government Printing Office, Washington, D. C., printed for the Weather Bureau.

SPECIAL ARTICLES

THE SIPHON IN TEXT-BOOKS

THE treatments commonly accorded to the siphon in text-books of physics of college grade may be classified in three groups. I have attempted to reduce the characteristic features of each group to a typical or standard form. There is no intention to quote and italics are strictly mine. Reference is made to the diagram, which will serve in common for the three methods of treatment.



I. The pressure at *A* is the resultant of an *upward* pressure equal to the atmospheric pressure and a *downward* pressure due to the column of liquid *AB*. The pressure at *D* is the resultant of an *upward* pressure equal to the atmospheric pressure and a *downward* pressure due to the column of liquid *DB*. As *DB* is greater than *AB*, the resultant pressure

upward at *A* is greater than that at *D*. The liquid *must therefore flow* from *A* to *D*.

It is evident from this discussion that a siphon can not operate if *AB* is greater than the barometric height for the liquid in question.

II. If we consider the pressures *acting at C* we will find that the pressure *toward D* is the atmospheric pressure minus the pressure represented by a column of liquid *AB*, while the pressure *toward A* is the pressure of the atmosphere less the pressure represented by the column of liquid *DB*. The resultant pressure is therefore *toward D, determining a flow* in that direction.

It is evident from this discussion that a siphon can not operate if *AB* is greater than the barometric height for the liquid in question.

III. The end *D* being closed, and the siphon filled, the pressure at *D* will exceed atmospheric pressure by an amount represented by the column of liquid *DA*, since all points at the level of *A* are now at atmospheric pressure. Upon opening *D* this excess pressure causes the flow, and the atmospheric pressure at *A* keeps the tube filled.

It is evident from this discussion that a siphon can not operate if *AB* is greater than the barometric height for the liquid in question.

The refrain with which each treatment concludes is a noteworthy element of uniformity, to be considered below. Special features of criticism are as follows.

I. Pressure at a point within a body of fluid is not upward or downward, to left or to right, north, east, south or west. It is without direction.

The pressure at *A*, whether inside the tube or outside, and whether the siphon be flowing or not flowing, is never greater than the pressure at *D*.

The flow of a liquid between two points does not necessarily take place from high to low pressure. See the discussion below, based on Bernoulli's principle, of this particular case.

II. As above stated, pressure in a body of fluid is without direction. The pressure at *C* is neither toward *A* nor toward *D*, and certainly does not have unequal components in these two directions.

III. Except the concluding refrain, this treatment correctly represents the facts, and shows at least why the siphon ought to start flowing. Curiously enough, Bernoulli's principle and the law of diminution of potential energy having been known for a long time, little attempt is made to show what happens, and why, when the siphon is actually working, the discussions being chiefly hydrostatic.

If we assume that the siphon gives an example of steady frictionless irrotational flow of an incompressible fluid, an assumption probably justified as a first approximation, we can apply Bernoulli's principle.

Then, for any given stream tube

$$p + hdg + \tfrac{1}{2}dv^2 = \text{constant},$$

in which p represents fluid pressure, h height above any assigned zero level, g acceleration of gravity, d density of the fluid, and v the speed with which it is moving.

Considering now the siphon when in steady flow, and assuming the reservoir indefinitely large, we find that the stream lines begin at the free surface, widely spread, the liquid flowing here at a speed approaching zero; converge into the orifice of the short limb, with much increased speed; traverse the entire length of the tube, supposed of uniform cross section, without change in speed, and that the stream emerges finally at this speed.

At the surface *A outside the tube* the pressure is atmospheric. Inside the tube it is less than atmospheric, for the stream has gained speed at the same level. As the stream ascends, at uniform speed, the pressure diminishes continuously, the least pressure being reached at the highest point. Descending, at constant speed, the pressure increases until at the lower orifice *D* the pressure is once more atmospheric, and the stream emerges in pressure equilibrium with the air surrounding it.

Taking a stream tube beginning at surface *A* outside the tube, and ending at *D* we have

$p_1 = p_2 = P$ (atmospheric pressure),

$v_1 \doteq 0$, $v_2 = V$ (constant speed through tube),

and applying Bernoulli's principle

$$P + h_1 dg = P + h_2 dg + \tfrac{1}{2} dV^2,$$

whence

$$V^2 = 2g(h_1 - h_2) = 2g\overline{DA},$$

which expresses a simple interchange of potential and kinetic energy, corresponding strictly with the facts upon the assumption that the operation is frictionless.

It will be easy to express the reduced pressure at the level A, inside the tube, by comparing two points at level A, one outside, the other inside

We have, outside

$$p_1 = P \quad v_1 \doteq 0,$$

inside

$$h_1' = h_1 \quad v_1' = V,$$

and thus

$$p_1' + h_1' dg + \tfrac{1}{2} dV^2 = P + h_1 dg,$$

$$p_1' = P - \tfrac{1}{2} dV^2,$$

but

$$\tfrac{1}{2} dV^2 = dg(h_1 - h_2);$$

therefore

$$p_1' = P - dg(h_1 - h_2).$$

We can now discuss the invariable refrain or *coda* found in all the type treatments. It appears to be based upon the assumption that a liquid can not exist with a negative pressure, or as sometimes expressed, under tension. This is hardly true; there is considerable experimental evidence to the contrary. Let us make this assumption, however, and limit the working height of the siphon to that which makes the pressure zero at the highest point.

Comparing points C (at level B) and D we have

At C

$$p_0 = 0, \; v_0 = V.$$

At D

$$p_2 = P, \; v_2 = V.$$

$$h_0 dg + \tfrac{1}{2} dV^2 = P + h_2 dg + \tfrac{1}{2} dV^2;$$

whence

$$(h_0 - h_2) dg = P.$$

Now $h_0 - h_2$ is the difference in level between D and B, which is thus shown to equal the barometric height for the given liquid, in the assumed limiting case. The ordinary statement asserts that AB equals the barometric height in the limiting case, the loss of pressure at A inside the tube being overlooked, and the concept being hydrostatic rather than hydrokinetic.

This discussion is not original in substance; see some good treatises on hydrodynamics.

HAROLD C. BARKER

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

SECTION E—GEOLOGY AND GEOGRAPHY

THE seventy-second meeting of Section E (Geology and Geography) of the American Association for the Advancement of Science was held in the Soldan High School building in St. Louis, Mo., on December 30 and 31. In the absence of Professor Charles Kenneth Leith, the vice-president elect of Section E, Dr. David White, chief geologist of the U. S. Geological Survey, was voted chairman for the St. Louis meeting, and presided.

The address of the retiring vice-president, Dr. David White, upon the subject, "Geology as Taught in the United States," was given on the morning of December 31 in the main auditorium, before a joint session of the Association of American Geographers, the American Meteorological Society, and Section E. This address will be printed in full in SCIENCE.

The vice-president of Section E for the coming year will be elected by the executive committee at its meeting in April. Dr. Nevin M. Fenneman, of the University of Cincinnati, was elected member of the council.

The program which was so full that each session overran the allotted time, comprised the following papers:

The origin of glauconite: W. A. TARR. Glauconite is a hydrous silicate of iron and potash. The composition is variable, but the amount of potash rarely exceeds 8 per cent. The mineral is amorphous, and is usually some shade of green. It occurs as rounded grains and irregular areas in dolomites, limestones, conglomerates, marls, sandstones and shales. It is found in the Cambrian formations of Missouri, Oklahoma, Texas, South Dakota and Wyoming, and in the Cretaceous and Eocene formations along the Atlantic and Gulf coasts. Geographically and geologically, glauconite is associated with granites, usually being deposited

after a period of base leveling, when weathering had been proceeding a long time. This long-continued weathering is thought to have furnished colloidal silica, iron, potash and alumina to the sea water, where through the action of the saline matter in the sea water the silica and alumina were precipitated, while the iron was thrown down by oxidation. These colloids mingled in varying amounts and then absorbed the potash from the sea water, thus forming glauconite.

A Mauch Chunk Island in the Mississippian Seas of eastern Kentucky: Willard R. Jillson, state geologist of Kentucky, Frankfort, Kentucky. In the eastern Kentucky coal fields on the divide between the Licking River and the Levisa Fork of the Big Sandy River, there exists an elongated structurally elevated area of between 700 and 1,000 square miles. This structural high has been called the Paint Creek uplift and is located so as to overlap parts of Magoffin, Morgan, Elliott, Lawrence, Johnson and Floyd counties. The Paint Creek uplift has a slight east of north major axis as mapped structurally on the Pottsville Fire-Clay coal. The normal dip at the surface is slightly to the south of east. The Paint Creek uplift culminates in two pinnacles, the Paint Creek Dome and the Laurel Creek Dome. There exists a maximum reversal of about 250 feet. The considerable amount of oil and gas prospecting drilling on these structures during the past two years has resulted in defining two pronounced oil and gas fields, one on either dome. Production is secured principally from the Weir sand which correlates with the Cuyahoga sandstone in the Waverley group toward the base of the Mississippian system. An examination of the well records of recent drillings in this locality shows an increasing interval between the Fire Clay coal of the Pottsville and the Big Lime (St. Genevieve-St. Louis) of the Mississippian, as one proceeds away from the highest structural points.

A summary conception of the structure of the Weir sand shows it to be much more steeply tilted than the persistent coals of the surface Pottsville. The absence of expected thicknesses of the Mauch Chunk on the top of this structure and the thickness of the Pottsville and Mauch Chunk on the sides coupled with the steeper inclinations of the Weir sands suggests an anticlinal island in the Mississippian seas at this point during the latter part of the Mauch Chunk period with unconsolidated Mauch Chunk sediments, subjected to subaerial erosion. Following early Pottsville times, quiescent subsidence is conceived to have taken place, which was followed during the time of the Appalachian overthrusts by folding and faulting along, and transverse to, the major axis of the original Mississippian anticline.

A Geological Section from St. Louis to Kansas City: E. B. Branson.

The Pre-Moenkopi unconformity of the Colorado plateau: C. L. Dake. The area over which the unconformity was studied embraces the region from the Zuni uplift in New Mexico west to the Little Colorado River in Arizona, and northwest to the vicinity of the Henry Mountains in Utah. Sudden changes in the thickness of the Moenkopi amounting to two hundred feet or more, in short distances, show local erosion of at least that magnitude during the pre-Moenkopi erosion interval. Data gathered by the writer tend strongly to confirm a hypothesis advanced by Cross that the Permian rests on progressively younger beds as the unconformity is traced westwards, the erosion amounting perhaps to all the Kaibab, the Coconino and the Supai formations. In other words the Moenkopi Red beds rest on the Kaibab formation in the area about the Grand Canyon and probably west of the Henry Mountains, while farther east they rest on the Goodridge (correlated by Girty with the Redwall) in the San Juan region, and probably on equivalent beds near Moab. This would involve the erosion of approximately two thousand feet of Pennsylvanian strata in the eastern portion of the area under discussion, the equivalents of which are present farther west. This conclusion, if true, would place the pre-Moenkopi unconformity among those of larger significance in geologic history.

Notes on the geology of the Cove areas of east Tennesese: C. H. Gordon, University of Tennessee, Knoxville. Within the western foothills of the Unaka or Great Smoky Mountains in east Tennessee are a number of irregular open valleys known locally as "coves." The largest of these is Tuckeleeche Cove on Little River. Wear Cove to the northeast and Cades Cove on the southwest are about half as large. The coves are underlaid by the Knox dolomite uplifted in broad irregular domes with the overlying Wilhite slates outcropping in broad irregular bands around them. The more fertile soils of the coves early attracted settlers and each is now the locus of a prosperous settlement. This and the region to the southwest is the typical region of Safford's Ocoee rocks consisting of sandstones, conglomerates and slates

more or less metamorphosed. These rocks were placed by Safford in the Cambrian a reference at first questioned by the government geologists but afterwards accepted. In this area the Ocoee slates overlie the Knox dolomite the larger part of which is Ordovician. These relations indicate, therefore, the presence here of a great overthrust fault whereby the lower Ocoee rocks have been thrust over the Knox dolomite to the distance of eight or ten miles. Two periods of faulting are recognized in the region, the first of which is recorded in the above-mentioned overthrust of the Cambrian upon the Knox. Later came another stage of folding and faulting in which the faults of the first period were involved giving rise to complex structures not always easily decipherable. It was during this second period of movement that most of the great faults of the valley were produced.

The Oriskany sandstone faunule at Oriskany Falls, New York: HARRY N. EATON. The type locality of the Oriskany sandstone is at Oriskany Falls, in the southern part of Oneida county, New York, where a lower Devonian section is exposed. This occurrence has been known in the literature since 1839 when Vanuxem noted it in his state survey report. Structurally, the sandstone is a small lens, ten feet thick, whose southern edge only can be observed. The faunal list is interesting chiefly because it is larger than formerly supposed, and as showing relations to other faunules in New York and Ontario. This study was incidental to more detailed work on the Oriskany in another New York locality.

Salem limestone outliers in central Missouri: COURTNEY WERNER.

Geology of the Sullivan county, Indiana, oil field: STEPHEN S. VISHER. Approximately 30 miles south of Terre Haute, and only a few miles from the Illinois boundary, there are seven producing oil pools aggregating in area about 12 square miles. About 500 wells are being pumped. The daily production was recently about 1,000 barrels. No report on the geological conditions in this oil field has been published. A study carried on recently under the direction of State Geologist Logan, has revealed several interesting facts. Production is from four sands. The highest of these, at a depth of approximately 620 feet, seems clearly to be along the unconformity between the Allegheny and the Pottsville divisions of the Pennsylvania Formation. The three lower sands are in the Mansfield division of the Pottsville. The second sand is about 660 feet below the surface; the third about 740 and the fourth about 800 feet. The presence of more than one oil sand has not been recognized by most drillers. Many wells have been abandoned only a few feet above a sand in which wells not far away obtain profitable production. No proof of local folding or doming was obtained. The evidence at hand indicates that the oil pools are lenses of sand along the buried valley of an ancient aggrading river or rivers. The Indiana Geological Survey is publishing the full report.

The late Pleistocene submergence in the Columbia River valley: J. HARLEN BRETZ.

The latest glacial features in the United States: HERMAN L. FAIRCHILD. These features are depicted on maps of a forthcoming Bulletin of the New York State Museum, proofs of which are here exhibited. The locality is the north boundary of New York. Here, on the point of the northern salient of the Adirondack mass the waning Quebec (Labradorian) glacier made its last stand on American territory with the effect of impounding glacial waters. Probably the ice sheet abandoned northern Maine somewhat later. The extinction features of Lake Iroquois, the last and most interesting of the long series of glacial waters, lie here; these being the second outlet channel through Covey pass and the shoreline phenomena on the west. On the Champlain side of the highland are the remarkable denuded rock areas and channels produced by the latest glacial drainage held to high levels by the Champlain lobe of the wasting glacier. Beneath these glacial stream features on the east side of the salient, and the Iroquois shore on the west side, lies the shore of the sea-level waters, which had followed the receding ice front up the Hudson-Champlain valley. This "marine" shore, strongly marked by heavy cobble bars and deltas, curves around the north end of the salient (Covey Hill) and passes back into New York north of Chateaugay village. At Covey pass the Iroquois plane is to-day 1,030 feet altitude, and the marine beach is 740 feet. The difference, 290 feet, is the altitude of Lake Iroquois at the time of its down-draining into the Champlain Sea, which figure is the master key to the quantitative study of land deformation in the Ontario-St. Lawrence valley.

Springfield, Missouri and the frontier of 1820: LEWIS F. THOMAS. About 1820 white settlers began to move into the Osage county of Missouri and settle in the more favored localities. One of these was the site of Springfield, which on account of a favorable combination of natural advantages out-

stripped all the other settlements. An abundant supply of sparkling water and a magnificent stand of walnut and oak timber determined the location of the cabins and stores. The near by grass lands were easily broken by the plow into fertile fields or left as open range lands for cattle. The greatest advantage was the location of the settlement, situated as it was on the broad undulating surface of the White-Osage River divide where an old north-south Indian trail intersected an east-west White River trail. These trails passed through the stages of road and pike to railroad. Back and forth over them moved the settlers and freight which gave life to the city and made it the social, political, manufacturing and commercial center of southwestern Missouri. Thus Springfield has been from the beginning of settlement a densely settled population outlier in the sparcely settled Ozark region.

The Chester series in Illinois: Stuart Weller. The original section of the Mississippian formation is that along the Mississippi River in Iowa and Illinois. The upper portion of this section constituting the "Chester Group" of Worthen is typically exposed in southern Illinois. This succession of strata is now considered to be of *Series* rank, and the upper Mississippian is now called the Chester Series, while the name Iowa Series is suggested for the lower Mississippian. In the course of detailed mapping in southern Illinois, in progress since 1911, the Chester Series has been subdivided into sixteen distinct formational units. In the more complete section, as exhibited in Pope and Johnson counties, these formations are alternately sandstone and calcareous members, the calcareous members being made up of considerable amounts of shale interbedded with limestone. The names used for these formations are as follows: *Upper Chester*—16, Kinkaid limestone; 15, Degonia sandstone; 14, Clore limestone; 13, Palestine sandstone; 12, Menard limestone; 11, Waltersburg sandstone; 10, Vienna limestone; 9, Tar Springs sandstone. *Middle Chester*—8, Glen Dean limestone; 7, Hardensburg sandstone; 6, Golconda limestone; 5, Cypress sandstone. *Lower Chester*—4, Paint Creek limestone; 3, Yankeetown formation and Bethel sandstone; 2, Renault limestone; 1, Aux Vases sandstone. The limestone members of this series of formations, with the possible exception of the Vienna, exhibit a continuous distribution across the state from Hardin county at the southeast to Randolph and Monroe counties at the northwest, but most of the sandstones are not continuously present. The Aux Vases sandstone has its greater development in the Mississippi River section and thins out to the southeast, being very certainly wanting in the section east of Union county. The Bethel, Cypress, Hardensburg and Tar Springs sandstones have their great development in the southeast and are either wanting in the Mississippi River section, or are represented by more or less discontinuous, thin beds. The Waltersburg sandstone has its great development in Pope and Johnson counties and thins out both to the east and the west. The Palestine and Degonia sandstones are about equally developed across the entire Chester area in the state.

Correlation of the Upper Paleozoic rocks of the Hueco Mountain region of Texas: J. W. Beede.[1] Three great groups of rocks, the Mississippian, Pennsylvanian and Permian, each separated from the beds beneath them by unconformity, are represented in the Hueco region of Hudspeth county, Texas. The Mississippian is composed of some 500 feet of limestones and shales, and is referred to the Chester Group by Weller. Eleven hundred feet of Magdalena beds composed of limestones and marls represent the Des Moines Group of the Pennsylvanian system. The Manzano Group corresponds to the Wichita beds of central Texas and the Neva limestone to Summer Series of Kansas. The Abo sandstone of New Mexico appears to be wanting at localities studied; but belongs to Upper Pennsylvanian system. These beds are followed by strong unconformity carrying 100 feet of foreign conglomerate which cuts diagonally across the upper beds and the Diablo plateau to the northern Salt Flat. It is followed by part of the Leonard formation and farther south the Word formation comes in. This unconformity appears to be the one at the base of the Leonard formation in the Glass Mountains which extends from Salt Flat southwest to the Hueco and southeast to the Glass Mountains. From there northeastward to eastern Coke county and Red River, and probably into Kansas. It is the surface on which the Double Mountain beds were deposited.

The Devonian rocks of southwestern Illinois: T. E. Savage. The Devonian rocks in the lower Mississippian embayment have an aggregate thickness of nearly 1,000 feet. Of these, a thickness of more than 800 feet occur in southwest Illinois. In this state these rocks do not extend as far north as St. Louis, and their outcrops are restricted to

[1] Published by permission of the director of the Bureau of Economic Geology and Technology, University of Texas.

a belt a few miles wide near the Mississippi River. In this succession of strata all of the series, or larger divisions, of the Devonian system recognized in the New York section are present, as shown in the following table of formations:

Devonian formations present in southwest Illinois:

Upper Devonian.
  Chautauquan series.
    Mountain Glen shale, 45 feet.
  Senecan series.
    Alto formation, 90 feet.
Middle Devonian.
  Erian series.
    Lingle limestone, 90 feet.
    Misenheimer shale, 35 feet.
  Ulsterian series.
    Grand Tower limestone, 125 feet.
    Dutch Creek sandstone, 30 feet.
    Clear Creek chert, 300 feet.
Lower Devonian.
  Oriskanian series.
    Rocks of this age are not known to occur in the state, but they are present farther northwest in Missouri; and farther southeast, in western Tennessee. Remnants are probably present in Illinois, but concealed beneath younger strata.
  Helderbergian series.
    Back-bone limestone, 65 feet.
    Bailey limestone, 100 feet.

ROLLIN T. CHAMBERLIN,
Secretary

(To be continued)

THE AMERICAN GEOPHYSICAL UNION

THE first annual meeting of the American Geophysical Union was held in the forenoon of April 23, 1920, at the offices of the National Research Council in Washington. At this meeting the permanent organization of this body was completed, amendments to its statutes were adopted, by-laws were enacted, officers of the Union were elected and the elections of officers of the sections conducted by mail ballot were ratified.

Reports were submitted by the American officers of the sections of the International Geodetic and Geophysical Union describing the progress made in the organization of these international sections. A report was submitted from the acting executive committee covering the work of preparation for the annual meeting.

A brief exposition was given of the status and functions of the American Geophysical Union, on the one hand, in relation to the parent bodies, the International Research Council, the National Research Council and the International Geodetic and Geophysical Union, and on the other, in relation to the branches of science embraced under the term "geophysics" and specifically included in the sections of the union.

For each of the sections addresses were made by the chairman, setting forth in outline various problems of interest to the sections. These addresses constituted brief surveys of the research needs of the various branches of geophysics. They will be prepared for publication and issued at a later date.

Officers were elected to serve from July 1, 1920, as follows: American Geophysical Union: *Chairman*, Wm. Bowie for two years; *Vice-chairman*, L. A. Bauer, for two years; *Secretary*, H. O. Wood, for three years; Section (*a*), Geodesy; *Chairman*, Wm. Bowie, for two years; *Vice-chairman*, J. F. Hayford, for two years; *Secretary*, H O. Wood, for three years; Section (*b*), Seismology; *Chairman*, H. F. Reid, for two years; *Vice-chairman*, J. C. Branner, for two years; *Secretary*, H. O. Wood, for three years; Section (*c*), Meteorology, *Chairman*, C. F. Marvin, for two years; *Vice-chairman*, W. J. Humphreys, for two years; *Secretary*, A. J. Henry, for three years; Section (*d*), Terrestrial Magnetism and Electricity, *Chairman*, L. A. Bauer, for two years; *Vice-chairman*, W. F. G. Swann, for two years; *Secretary*, J. A. Fleming, for three years; Section (*e*), Physical Oceanography; *Chairman*, G. W. Littlehales, for two years; *Vice-chairman*, tie vote, no election; *Secretary*, J. T. Watkins, for three years; Section (*f*) Volcanology; *Chairman*, H. W. Washington, for two years; *Vice-chairman*, R. A. Daly, for two years; *Secretary*, H. O. Wood, for three years.

HARRY O. WOOD,
Secretary

THE NATIONAL ACADEMY OF SCIENCES

THE program of the scientific sessions of the annual meeting, held in Washington on April 26 and 27, was as follows:

MONDAY, APRIL 26

Morning Session

Conservation of natural resources as a proper function of the National Academy: JOHN M. CLARKE.

On the rate of growth of the population of the United States since 1790 and its mathematical expression: RAYMOND PEARL.

Growth and development as determined by environmental influences: FRANZ BOAS.

Plural births in man: Charles B. Davenport.

Dynamical aspects of injury, recovery and death: W. J. V. Osterhout.

The importance of the presence of both sympathetic superior cervical ganglia to the maintenance of life; and their possible relations to respiratory diseases: Samuel J. Meltzer.

The National Research Council: James R. Angell.

A psychological study of the medical officers in the Army: Robert M. Yerkes.

Afternoon Session

Spectroscopic phenomena of very long vacuum tubes: Robert W. Wood.

The measurement of small time intervals and some applications, principally ballistic (introduced by Arthur G. Webster): L. T. E. Thompson, C. N. Hickman and N. Riffolt.

The effect of molecular structure upon the reflection of molecules from the surface of liquids and solids: Robert A. Millikan.

The Springfield rifle and the Leduc formula: Arthur G. Webster.

On the internal ballistics of the Springfield rifle: Arthur G. Webster.

The 100-inch Hooker telescope of the Mt. Wilson Observatory: George E. Hale.

The vertical interferometer: Preliminary tests in an attempt to measure the diameter of the stars; A modification of the Foucault method adapted to long-distance measurement of the velocity of light: A. A. Michelson.

Preliminary measurements on the pressures in the "Onde de Choc": Arthur G. Webster.

On the specific heat of powder gases: Arthur G. Webster.

Thermal conductivity of metals: Edwin H. Hall.

Evening Session

The scale of the universe: Harlow Shapley, Mount Wilson Solar Observatory, and Heber D. Curtis, Lick Observatory (open to the public). U. S. National Museum (main auditorium). (William Ellery Hale Lectures.)

TUESDAY, APRIL 27

Morning Session

Distribution and villages of the Indian tribes of the Klamath River region, California: C. Hart Merriam.

Significance of correlation in function between the dentition and skeleton of the Sabre-tooth tiger: John C. Merriam.

On the colonial nervous system of Renilla: George H. Parker.

The genus Botrychium and its relationships: Douglas H. Campbell.

The influence of cold in stimulating the growth of plants: Frederick V. Coville.

Some common foods as sources of vitamines: Thomas B. Osborne and Lafayette B. Mendel.

The physico-chemical properties of hæmoglobin: Lawrence J. Henderson.

The direct combination of nitrogen and chlorine: William A. Noyes.

Valance and chemical affinity: Gilbert N. Lewis.

Afternoon Session

Shock of water ram in pipe lines with imperfect reflection at the discharge end and including the effect of friction and non-uniform change of valve opening: William F. Durand.

Recent notable progress in the theory of numbers: Leonard E. Dickson.

Geodesics and relativity: Edward Kasner.

The use of alternating currents for submarine cable transmission (introduced by G. O. Squier): F. E. Pernot.

Improvements in telegraphy: George O. Squier.

The air resistance of spheres: Lyman J. Briggs.

The possibilities of the rocket in weather forecasting: Robert H. Goddard.

The distribution of land and water on the earth: H. Fielding Reid.

The alterations of limestones in contact-metamorphism: Waldemar Lindgren.

Structure of Marrella and allied middle Cambrian crustaceans: Charles D. Walcott.

On a single numerical index of the age distribution of a population (by title): Raymond Pearl.

Biographical memoir of George Jarvis Brush (by title): Edward S. Dana.

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